IN THE CLAIMS

Please amend the claims as follows, substituting any amended claim(s) for the corresponding pending claim(s):

1. (Original) A radio frequency integrated circuit (RFIC) comprises:

transmitter section operably coupled to convert outbound baseband signals into outbound radio frequency (RF) signals;

receiver section operably coupled to convert inbound RF signals into inbound baseband signals, wherein the receiver section includes: a low noise amplifier operably coupled to amplify the inbound RF signals to produce amplified inbound RF signals;

down-conversion module operably coupled to convert the amplified inbound RF signals into baseband in-phase components and quadrature components;

orthogonal-normalizing module operably coupled to:

obtain a first coefficient that is based on at least one of power of the baseband in-phase components, power of the baseband quadrature components, and cross-correlation between the baseband in-phase components and the baseband quadrature components;

obtain a second coefficient that is based on at least one of the power of the baseband in-phase components, the power of the baseband quadrature components, and the cross-correlation between the baseband in-phase components and the baseband quadrature components;

normalize an orthogonal relationship between the baseband in-phase components and the baseband quadrature components based on the first coefficient and the second coefficient to produce normalized in-phase components and normalized quadrature components; and

baseband processor operably coupled to recapture data from the normalized in-phase and quadrature components.

2. (Original) The RFIC of claim 1, wherein the orthogonal-normalizing module comprises:

a first multiplier module operably coupled to multiple the baseband in-phase components with the first coefficient to produce the normalized in-phase components;

a second multiplier module operably coupled to multiple the baseband in-phase components with the second coefficient to produce the cross-correlation; and

a subtraction module operably coupled to subtract the cross-correlation from the baseband quadrature components to produce the normalized quadrature components.

3. (Original) The RFIC of claim 2, wherein the first multiplier module comprises:

a first plurality of shift registers operably coupled to produce a plurality of shifted representations of the baseband in-phase components;

switch matrix operably coupled to pass selected ones of the plurality of shifted representations of the baseband in-phase components and the baseband in-phase components based on the first coefficient; and

an adder operably coupled to add the selected ones of the plurality of shifted representations of the baseband in-phase components and the baseband in-phase components to produce the normalized in-phase components.

4. (Original) The RFIC of claim 2, wherein the second multiplier module comprises:

a first plurality of shift registers operably coupled to produce a plurality of shifted representations of the baseband in-phase components;

switch matrix operably coupled to pass selected ones of the plurality of shifted representations of the baseband in-phase components based on the second coefficient; and

an adder operably coupled to add the selected ones of the plurality of shifted representations of the baseband in-phase components to produce the cross-correlation.

5. (Original) The RFIC of claim 1, wherein the orthogonal-normalizing module comprises:

a first multiplier module operably coupled to multiply the baseband in-phase components with the second coefficient to produce the cross-correlation;

a subtraction module operably coupled to subtract the cross-correlation from the baseband quadrature components to produce phase adjusted quadrature components; and

a second multiplier module operably coupled to multiply the phase adjusted quadrature components with the first coefficient to produce the normalized quadrature components, wherein the baseband in-phase components are passed as the normalized in-phase components.

6. (Currently Amended) The RFIC of claim 1, wherein the orthogonal-normalizing module comprises:

a first programmable register for storing the first coefficient; and

a second programmable register for storing the second coefficient, wherein the first and second coefficients are determined by a ~~trail and error manufacturing test~~ <u>trial and error manufacturing test</u>.

7. (Original) The RFIC of claim 1, wherein the orthogonal-normalizing module comprises:

a full matrix multiply module operably coupled to multiply the baseband in-phase components and the baseband quadrature components with a coefficient matrix that includes the first and second coefficients to produce the normalized in-phase components and the normalized quadrature components.

8. (Original) The RFIC of claim 1, wherein the orthogonal-normalizing module further functions to:

measure local oscillation leakage power to produce a first power measurement;

provide a first magnitude signal to an in-phase portion of the receiver section and a zero magnitude signal to a quadrature portion of the receiver section;

measure power of the in-phase portion and power of the quadrature portion while processing the first magnitude signal and the zero magnitude signal, respectively, to produce a second power measurement;

provide the first magnitude signal to the quadrature portion of the receiver section and the zero magnitude signal to the in-phase portion of the receiver section;

measure the power of the in-phase portion and the power of the quadrature portion while processing the zero magnitude signal and the first magnitude signal, respectively, to produce a third power measurement;

determine a gain imbalance based on the first, second, and third power measurements;

provide a second magnitude signal to the in-phase portion and to the quadrature portion;

measure the power of the in-phase and quadrature portions while processing the second magnitude signal to produce a fourth power measurement;

provide the second magnitude signal to the in-phase portion and a negative second magnitude signal to the quadrature portion;

measure the power of the in-phase portion and the power of the quadrature portion while processing the second magnitude signal and the negative second magnitude signal, respectively, to produce a fifth power measurement; and

determine a phase imbalance based on the first, fourth, and fifth power measurements, wherein the gain imbalance and the phase imbalance correspond to the power of the baseband in-phase components, the power of the baseband quadrature components, and the cross-correlation between the baseband in-phase components and the baseband quadrature components to determine the first and second coefficients.

9. (Original) The RFIC of claim 1, wherein the orthogonal-normalizing module further functions to obtain the first and second coefficients by:

measuring in-phase signal level of the receiver section while processing a sine wave;

measuring quadrature signal level of the receiver section while processing the sine wave;

determining the power of the baseband in-phase components based on the in-phase signal level;

determining the power of the baseband quadrature components based on the quadrature signal level;

determining cross-correlation power based on the in-phase signal level and the quadrature signal level; and

determining the first and second coefficients based on the power of the baseband in-phase components, the of the baseband quadrature components, and the cross-correlation power.

10. (Original) The RFIC of claim 1, wherein the orthogonal-normalizing module normalizes the orthogonal relationship between the baseband in-phase components and the baseband quadrature components by:

selecting one of the baseband in-phase components and the baseband quadrature components as a reference component; and

normalizing another one of the baseband in-phase components and the baseband quadrature components to the reference component.

11. (Original) The RFIC of claim 1, wherein the orthogonal-normalizing module further functions to: update the first and second coefficients to compensate for at least one of temperature variation and aging.

12. (Original) A radio frequency integrated circuit (RFIC) comprises:

transmitter section operably coupled to convert outbound baseband signals into outbound radio frequency (RF) signals;

receiver section operably coupled to convert inbound RF signals into inbound data, wherein the receiver section includes: a low noise amplifier operably coupled to amplify the inbound RF signals to produce amplified inbound RF signals;

down-conversion module operably coupled to convert the amplified inbound RF signals into baseband in-phase components and quadrature components;

orthogonal-normalizing module including:

an in-phase power module operably coupled to determine power of the baseband in-phase components;

a quadrature power module operably coupled to determine power of the quadrature components;

a cross-correlation power module operably coupled to determine a cross-correlation power based on the baseband in-phase and quadrature components; and

normalizing module operably coupled to normalize the baseband in-phase components and the baseband quadrature components based on the power of the baseband in-phase components, the power of the baseband quadrature components, and the cross-correlation power to produce normalized in-phase components and normalized quadrature components; and

baseband processor operably coupled to recapture the inbound data from the normalized in-phase and quadrature components.

13. (Original) The RFIC of claim 12, wherein the normalizing module comprises:

a coefficient module operably coupled to determine coefficients based on the power of the baseband in-phase components, the power of the baseband quadrature components, and the cross-correlation power, wherein the baseband in-phase components and the baseband quadrature components are normalized based on the coefficients.

14. (Original) The RFIC of claim 12, wherein the in-phase power module comprises:

a multiplier operably coupled to square the baseband in-phase components to produce squared in-phase values; and

an accumulator operably coupled to accumulate the squared in-phase values for a predetermined period of time to produce the power of the baseband in-phase components.

15. (Original) The RFIC of claim 12, wherein the quadrature power module comprises:

a multiplier operably coupled to square the baseband quadrature components to produce squared quadrature values; and

an accumulator operably coupled to accumulate the squared quadrature values for a predetermined period of time to produce the power of the baseband quadrature components.

16. (Original) The RFIC of claim 12, wherein the cross-correlation power module comprises:

a multiplier operably coupled to multiply the baseband in-phase components and the baseband quadrature components to produce cross-correlation values; and

an accumulator operably coupled to accumulate the cross-correlation values for a predetermined period of time to produce the cross-correlation power.

17. (Original) A radio frequency integrated circuit (RFIC) comprises:

receiver section operably coupled to convert inbound radio frequency (RF) signals into inbound baseband signals;

transmitter section operably coupled to convert outbound data into outbound RF signals, wherein the transmitter section includes:

baseband processor operably coupled to convert the outbound data into the baseband in-phase components and baseband quadrature components;

orthogonal-normalizing module operably coupled to:

obtain a first coefficient that is based on at least one of a gain imbalance and phase imbalance;

obtain a second coefficient that is based on at least one of the gain imbalance and the phase imbalance;

normalize an orthogonal relationship between the baseband in-phase components and the baseband quadrature components based on the first coefficient and the second coefficient to produce normalized in-phase components and normalized quadrature components;

up-conversion module operably coupled to convert the normalized in-phase components and normalized quadrature components into RF signals; and

power amplifier operably coupled to amplify the RF signals to produce the outbound RF signals.

18. (Original) The RFIC of claim 17, wherein the orthogonal-normalizing module comprises:
a first multiplier module operably coupled to multiple the baseband in-phase components with the first coefficient to produce the normalized in-phase components;
a second multiplier module operably coupled to multiple the baseband in-phase components with the second coefficient to produce cross coupled in-phase components; and
a subtraction module operably coupled to subtract the cross coupled in-phase components from the baseband quadrature components to produce the normalized quadrature components.

19. (Original) The RFIC of claim 18, wherein the first multiplier module comprises:
a first plurality of shift registers operably coupled to produce a plurality of shifted representations of the baseband in-phase components;
switch matrix operably coupled to pass selected ones of the plurality of shifted representations of the baseband in-phase components and the baseband in-phase components based on the first coefficient; and
an adder operably coupled to add the selected ones of the plurality of shifted representations of the baseband in-phase components and the baseband in-phase components to produce the normalized in-phase components.

20. (Original) The RFIC of claim 18, wherein the second multiplier module comprises:
a first plurality of shift registers operably coupled to produce a plurality of shifted representations of the baseband in-phase components;
switch matrix operably coupled to pass selected ones of the plurality of shifted representations of the baseband in-phase components based on the second coefficient; and
an adder operably coupled to add the selected ones of the plurality of shifted representations of the baseband in-phase components to produce the cross coupled in-phase components.

21. (Original) The RFIC of claim 17, wherein the orthogonal-normalizing module comprises:
a first multiplier module operably coupled to multiply the baseband in-phase components with the second coefficient to produce cross coupled in-phase components;
a subtraction module operably coupled to subtract the cross coupled in-phase components from the baseband quadrature components to produce phase adjusted quadrature components; and
a second multiplier module operably coupled to multiply the phase adjusted quadrature components with the first coefficient to produce the normalized quadrature components, wherein the baseband in-phase components are passed as the normalized in-phase components.

22. (Currently Amended) The RFIC of claim 17, wherein the orthogonal-normalizing module comprises:

a first programmable register for storing the first coefficient; and

a second programmable register for storing the second coefficient, wherein the first and second coefficients are determined by a ~~trail and error~~ trial and error manufacturing test of the gain imbalance and the phase imbalance.

23. (Original) The RFIC of claim 17, wherein the orthogonal-normalizing module comprises:

a full matrix multiply module operably coupled to multiply the baseband in-phase components and the baseband quadrature components with a coefficient matrix that includes the first and second coefficients to produce the normalized in-phase components and the normalized quadrature components.

24. (Original) The RFIC of claim 17, wherein the orthogonal-normalizing module further functions to:

measure local oscillation leakage power to produce a first power measurement;

provide a first magnitude signal to an in-phase portion of the transmitter section and a zero magnitude signal to a quadrature portion of the transmitter section;

measure power of the in-phase portion and power of the quadrature portion while processing the first magnitude signal and the zero magnitude signal, respectively, to produce a second power measurement;

provide the first magnitude signal to the quadrature portion of the transmitter section and the zero magnitude signal to the in-phase portion of the transmitter section;

measure the power of the in-phase portion and the power of the quadrature portion while processing the zero magnitude signal and the first magnitude signal, respectively, to produce a third power measurement;

determine the gain imbalance based on the first, second, and third power measurements;

provide a second magnitude signal to the in-phase portion and to the quadrature portion;

measure the power of the in-phase and quadrature portions while processing the second magnitude signal to produce a fourth power measurement;

provide the second magnitude signal to the in-phase portion and a negative second magnitude signal to the quadrature portion;

measure the power of the in-phase portion and the power of the quadrature portion while processing the second magnitude signal and the negative second magnitude signal, respectively, to produce a fifth power measurement; and

determine the phase imbalance based on the first, fourth, and fifth power measurements.

25. (Original) The RFIC of claim 17, wherein the orthogonal-normalizing module normalizes the orthogonal relationship between the baseband in-phase components and the baseband quadrature components by:

selecting one of the baseband in-phase components and the baseband quadrature components as a reference component; and

normalizing another one of the baseband in-phase components and the baseband quadrature components to the reference component.

26. (Original) The RFIC of claim 17, wherein the orthogonal-normalizing module further functions to:

update the first and second coefficients to compensate for at least one of temperature variation and aging.

27. (Original) A method for orthogonal normalization of a radio frequency integrated circuit (RFIC), the method comprises:

determining phase imbalance and gain imbalance of a transmitter section of the RFIC;

normalizing baseband in-phase components and baseband quadrature components of the transmitter section based on the phase imbalance and the gain imbalance of the transmitter section;

coupling the transmitter section to a receiver section of the RFIC in a loop back configuration;

providing a test signal from the transmitter section to the receiver section;

determining power of baseband in-phase components, power of baseband quadrature components, and cross-correlation between the baseband in-phase components and the baseband quadrature components of the receiver section while processing the test signal; and

normalizing the baseband in-phase components and the baseband quadrature components of the receiver section based on the power of the baseband in-phase components, the power of the baseband quadrature components, and the cross-correlation between the baseband in-phase components and the baseband quadrature components.

28. (Original) The method of claim 27, wherein the normalizing the baseband in-phase components of the receiver section comprises:

multiplying the baseband in-phase components with the first coefficient to produce the normalized in-phase components;

multiplying the baseband in-phase components with the second coefficient to produce the cross-correlation; and

subtracting the cross-correlation from the baseband quadrature components to produce the normalized quadrature components.

29. (Original) The method of claim 27, wherein the determining phase imbalance and gain imbalance of a transmitter section comprises:

measuring local oscillation leakage power to produce a first power measurement;

providing a first magnitude signal to an in-phase portion of the transmitter section and a zero magnitude signal to a quadrature portion of the transmitter section;

measuring power of the in-phase portion and power of the quadrature portion while processing the first magnitude signal and the zero magnitude signal, respectively, to produce a second power measurement;

providing the first magnitude signal to the quadrature portion of the transmitter section and the zero magnitude signal to the in-phase portion of the transmitter section;

measuring the power of the in-phase portion and the power of the quadrature portion while processing the zero magnitude signal and the first magnitude signal, respectively, to produce a third power measurement;

determining the gain imbalance based on the first, second, and third power measurements;

providing a second magnitude signal to the in-phase portion and to the quadrature portion;

measuring the power of the in-phase and quadrature portions while processing the second magnitude signal to produce a fourth power measurement;

providing the second magnitude signal to the in-phase portion and a negative second magnitude signal to the quadrature portion;

measuring the power of the in-phase portion and the power of the quadrature portion while processing the second magnitude signal and the negative second magnitude signal, respectively, to produce a fifth power measurement; and

determining the phase imbalance based on the first, fourth, and fifth power measurements.

30. (Original) The method of claim 27, wherein the determining the power of baseband in-phase components, the power of baseband quadrature components, and the cross-correlation comprises:

measuring in-phase signal level of the receiver section while processing the test signal; measuring quadrature signal level of the receiver section while processing the test signal;

determining the power of the baseband in-phase components based on the in-phase signal level;

determining the power of the baseband quadrature components based on the quadrature signal level; and

determining cross-correlation power based on the in-phase signal level and the quadrature signal level.

31. (Original) The method of claim 27 further comprises:

repeating the normalizing of the transmitter section and the receiver section to fine tune an orthogonal relationship between the baseband in-phase components and baseband quadrature components of the transmitter section and an orthogonal relationship between the baseband in-phase components and baseband quadrature components of the receiver section.

32. (Original) The method of claim 27 further comprises, in an ordered sequence:

coupling the transmitter section to the receiver section in the loop back configuration;

providing the test signal from the transmitter section to the receiver section;

determining the power of baseband in-phase components, the power of baseband quadrature components, and the cross-correlation between the baseband in-phase components and the baseband quadrature components of the receiver section while processing the test signal;

normalizing the baseband in-phase components and the baseband quadrature components of the receiver section based on the power of the baseband in-phase components, the power of the baseband quadrature components, and the cross-correlation between the baseband in-phase components and the baseband quadrature components;

determining the phase imbalance and the gain imbalance of the transmitter section;

normalizing baseband in-phase components and baseband quadrature components of the transmitter section based on the phase imbalance and the gain imbalance of the transmitter section; and

repeating the ordered sequence of normalizing of the receiver section and the transmitter section to fine tune an orthogonal relationship between the baseband in-phase components and baseband quadrature components of the receiver section and an orthogonal relationship between the baseband in-phase components and baseband quadrature components of the transmitter section.